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# The Effects of Bio-Slurry Fertilizer on *Sorghum bicolor* and *Centrosema pubescens* Planted with Inter-Cropping

*[1]Budiman Nohong, [2]Tanrigiling Rasyidand [3]Muhammad Yusuf

*[1]Department of Forage Crops and Grassland Management, Faculty of Animal Husbandry, Hasanuddin University, Makassar, Indonesia 90245.
[2]Department of Social Economic, Faculty of Animal Husbandry, Hasanuddin University, Makassar, 90245, Indonesia
[3] Forestry extension agencies Bone regency South Sulawesi Indonesia.

**Abstract**

The aim of this study was to determine the effect of Fertilizer bio-slurry (urine-cow) against the production of dry matter, crude protein and competitiveness of plants Sorghum (Sorghum bicolor) and Centro (Centrosema pubescens) planted with monocultures (single) and poly ( intercropping).The experiment was arranged in a factorial design consisting of three cropping systems, two levels of fertilizers and three replications. Cropping systems consist of sorghum and centro each planted single (sole) and sorghum-centro intercropping (2:2). Plants were fertilized by 0 liter of bio-slurry/ha and 25,000 liters of bio-slurry/ha (217.5 kg N/ha, 197.5 kg P2O5/ha and 230 kg K2O / ha), or equivalent to 125 ml/ polybag (1, 1 g N/polybag, 1.0 g P2O5 /polybag and 1.2 g K2O). Polybags in a size of 35 x 35 cm were filled by clay loam with ultisol texture weighing 10 kg on the field capacity condition. As many as six polybags were planted with eight sorghum grains; six polybags were planted with eight seeds of centro; while the other six polybags were planted with four sorghum grains and four centroseeds. The results showed that the use of bio-slurry markedly increase the production of dry matter and crude protein content of Sorghum and Centro. Sorghum ferilzed by bio-slurry is more dominant indicated by its higher relative crowding coefficient (RCC), competitive ratio (CR) and positive sign on aggressiveness. Sorghum is grown with a more aggressive manner in utilizing resources than centro because it has greater competitiveness than centro.

**Keywords:** bio-slurry. centro, competitiveness, intercropping, sorghum.

*Correspondingauthor:Department of Forage Crops and Grassland Management, Faculty of Animal Husbandry, Hasanuddin University, Makassar, Indonesia 90245.

## Introduction

Intercropping is the cultivation of two or more crops or crop species, or genotypes, growing together at the same time in the same field (Ouma and Jeruto, 2010 and Brooker *et al.,* 2015). Sorghum has a good quality if it is grown along with legumes that propagates (Patel and Rajagopal 2003). Cereal-legume intercropping appears to be a useful component of ecological intensificationan approach to produce more food per unit resource to achieve positive social outcomes without negative effects on the environment (Dore *et al.,* 2011 andHochman *et al.,* 2011). Intercropping of cereal and legumes contributes to maintain and improve soil fertility (Tsubo *et al.,* 2005). Legumes can transfer N for serealia during the growing period, and N is an important resource for serealia (Shen and Chu, 2004). Planting legumes and serealia altogether for food production is not only popular among farmers in the tropics, who produce most of the food in developing countries, but also it is developing into warm regions in the subtropics (Fujita *et al.,* 1992).

The main obstacles in improving and maintaining productivity and quality of forage on marginal land include lack of availability of nitrogen and water to support plant life. Meanwhile, the superior agricultural system has a superior specification of nitrogen (N), a demand that cannot be provided by reserved N substrance in the soil. Consequently, an additional input is required (Senbayram *et al.,* 2016). However, N application will continue to accelerate the decrease of the non-renewable energy resources used in the production of fertilizers (Bohlool *et al.,* 1992), and the applications of organic and inorganic nitrogen fertilizers lead to a risk of inevitable ecological damages and a decline in production which make the cost of agricultural production tend to increase due to the decrease in soil pH of 0.5 units, in main crop production areas for two decades, and they have been attributed to excessive applications of N fertilizer (Guo *et al.,* 2010).

The agricultural system relying heavily on land reservation to fulfil the needs of N plants is unable to stay effective on producing high yields of crops (Stevenson, 1982). Except for legumes, they have the ability to fix their own N. Therefore, symbiotic N2 fixation of legumes is widely utilized to increase the supply of N from the system. In addition to meeting the needs of N, legumes are able to facilitate the N intake from the surrounding plant species (Pirhofer-Walzl *et al.,* 2012).

Nowadays, a large number of unfortunate farmers cannot afford to buy fertilizers in sufficient quantities due to their high prices (Sisworo, 2006). Synthetic fertilizers are categorized as expensive commodities whose price is predicted to increase every year due to the decrease of their availability and the rising cost of fuel (Gensch *et al.,* 2011). This increase is assumed to bring serious implications for serealia grain production, particularly in industrialized countries located in subtropical areas as the main serealia producers (Preston, 2000). Due to the rising costs of chemical fertilizers and their inefficient role at producing long-term sustainable production, then, the application of organic fertilizers such as bio-slurry (cow urine) to increase the maximum productivity in a sustainable manner is required and to provide better quality of the soil (Raj *et al.,* 2014).

Bio-slurry is an organic source obtained as a product after the generation of biogas from the fermentor. Bio-slurry removed from the reactor retains all the basic nutrients available in foodsources, thus making bio-slurry as a potential organic fertilizer (SNV 2012), an environmentally friendly, inexpensive and renewable nutrient sources (Islam *et al.,* 2010), as well as a nutrient content resource in an available form (Bonten *et al.,* 2014). Nutrients in urine are available with a similar formulation to that of ammonia and urea resulting in comparable results for plant growth (Gensch *et al.,* 2011).

Efforts should be taken to build sustainable agricultural systems i.e. by optimizing the use of all external inputs that come from outside the system (Sanchez, 1994). One of the ways to perform the efforts is by supplying relatively inexpensive nutrients to utilize Biologcal Nitrogen Fixation (BNF). It is inarguable that BNF utilization is one of the N sources which is neccesary in sustainable agricultural systems (Danso, 1995). In addition to BNF system, utilization of bio-slurry as an N source is also important in agricultural systems. BNF and bio-slurry utilization as source of nutrients is a truly renewable agricultural system as a whole. Such practices would pave the way to reduce the use of external inputs and improve sustainability among organic farmers in developing countries (Devakumar *et al.,* 2014). This study aims to determine the effect of liquid bio-slurry Fertilizer (cattle-urine) against the production of dry matter, crude protein and competitiveness of Sorghum (*Sorghum bicolor*) and Centro plants (*Centrosemapubescens*) planted in monoculture (single) and polyculture (inter-cropping).

## Materials and Methods

This study was conducted at the Faculty of Animal Husbandry Research Station, University of Hasanuddin, Makassar, Indonesia (5°10 'S, 119°20' E) from January 2016 to March 2016. During this study, the averages of daily temperature, humidity and rainfall were 27°C, 85 %, and 390 mm, respectively. Clay loam with ultisol texture was utilized.

The experiment was arranged in a factorial design consisting of three cropping systems, two levels of fertilizers and three replications. Cropping systems consist of sorghum and centro each planted single (sole) and sorghum-centro intercropping (2:2). Plants were fertilized by 0 liter of bio-slurry/ha and 25,000 liters of bio-slurry/ha (217.5 kg N/ha, 197.5 kg $P_2O_5$/ha and 230 kg $K_2O$/ha), or equivalent to 125 ml/ polybag (1, 1 g N/polybag, 1.0 g $P_2O_5$/polybag and 1.2 g $K_2O$/polybag). Polybags in a size of 35 x 35 cm were filled by clay loam with ultisol texture weighing 10 kg on the field capacity condition. As many as six polybags were planted with eight sorghum grains; six polybags were planted with eight seeds of centro; while the other six polybags were planted with four sorghum grains and four centro seeds. Each seed was individually planted at a depth of 3 cm. To get the required plant population, thinning the plants is conducted by uprooting some plants that are not needed and leaving four plants/polybag for sorghum and centro treatment which were planted single (monoculture); and for sorghum intercropping with centro, each was left with two sorghum/polybag and two centro/polybag. Applying fertilizer is done by spraying it around the plants. Watering and weeding were also conducted if necessary.

### *Data Collection*

At harvest time, all the plants were harvested 5 cm above the ground by using scissors and weighed to determine the fresh weight. Thus, fresh samples chopped and dried in an oven at a temperature of 55°C for 3 days, and later they were weighed to determine the dried ingredients. Dried matter production = dry matter content x fresh weight production. All samples were milled (1 mm) with a grinding machine. This sample was used to determine the total nitrogen (N) by Kjeldahl method (AOAC, 2005), and crude protein (CP) was calculated by N x 6.25.

The competitiveness index was calculated using the competition index. Competition index has been widely used to determine the level of competition between species planted with intercropping system.

Competition index used in this study was relative yield Index (RY), relative yield total (ryt), relative crowding coefficient (RCC) and the aggressivity index (AI).

Relative yield (RY) and relative yield total (RYT) were counted by using Wiley's formulation (1979) as follows:

$RY_{Sorghum}$ = DMYss/DMYsi,

$RY_{Centrossema}$ = DMYcs/DMYci

RYT = $RY_{Sorghum} + RY_{Centro}$

Where: dry matter production of sole planted Sorghum plant.

DMYss = dry matter production of sorghum planted in

monoculture.

DMYcs = dry matter production of centro planted in

monoculture.

DMYsi = dry matter production of sorghum planted by

means of intercropping with centrol.

DMYci = dry matter production of centro grown by means of

intercropping with sorghum.

If RYT value is greater than one, it indicates that the species requires different resources to avoid competition. Meanwhile, if RYT value is less than one, it indicates a mutually antagonistic, and if RYT value equals to one, it indicates that the component species share the same limited resources (Harper, 1977).

LER was utilized as a criterion for the benefits of mixed stands. In particular, LER showed intercropping efficiency in using resources from the environment compared to single cropping (Mead and Willey 1980). If LER is greater than one, intercropping tends to be profitable and productive. On contrary, if LER is less than one (<1), intercropping affects negatively on the growth and crops yield planted in a mixture (Ofori and Stern 1987). This is a complementary indicator in which LER was calculated in reference to techniques proposed by Wiley and Osiru (1972) as follows:

LER = (YSC/YSS) + (YCS/CC),

Where:

YSC = Result of sorghum crops when intercropped (poly) with

plants centro.

YCS = Result of centro crops when intercropped (poly) with

sorghum.

YSS = Result of single grown sorghum (monoculture).

YCC = Result of single grown sentro (monoculture).

The relative crowding coefficient = RCC or K is a measure of the relative dominance of one species compared to other species in mixture (Willey and Rao 1980), calculated by the formulation of: RCC or K = (K Sorghum x K Centro), where K sorghum = YSI x Zcp / [(Yss - YSI) x ZSP], and K Centro = YCI x ZSP / [(YCS -Yci) x Zcp], where ZSP (= 2) and Zcp (= 2) are the proportion of sorghum and centro in mixture. Plant components that have a higher coefficient is considered to be more dominant. If the coefficient value of certain plants is less than one, the crop yields become less; if the coefficient value is equal to one, the result is the same, whereas when the coefficient value is greater than one, the result is more than it is "expected" ((Willey and Rao 1980).

Competition ratio = CR was measured to determine the competition level between plant crops in the cropping system (Bhatti 2006). This ratio reflects the individual competition of the two components of LER plants while taking into an account the proportion of crop planted.

Competition ratio of sorghum and cowpea in the mixture was calculated by the formula proposed by Willey *et al.,* (1980) as follows: CR = sorghum (sorghum LER / LER centro) (Zc / Zs), CR centro = (LER centro / LER sorghum) (Zs / Zc). Zs (= 2) and Zc (=2) are the proportion of sorghum and centro in the mixture.

Aggressivity indices = AI are a measure of the relation of competition between two crops in a mixed cropping (mixtures) (Willey, 1979). This is discussed by Dhima *et al.,* (2007) as follows: AI Sorghum = (YSI / Yss x Zp) - (YCI / YCS x Zc) and AI Centro = (YCI / YCS x Zc) -

(YSI / Yss x Zs). So, if AI sorghum is 0, both of these plants are equally competitive, if AI sorghum is positive, then the AI sorghum is more dominant; while if it is negative, then the sorghum is weaker.

## Statistical Analysis

The effects of treatment on dry matter production and crude protein content were calculated by using SPSS software (SPSS Ver. 16.0, SPSS Inc. Chicago, Illinois). Then, LSD test was carried out to examine the different treatments. The probability level of $P \leq 0.05$ is considered to be statistically significant.

The competitiveness index was calculated by using the competition index. Relative yield = RY and relative yield total = RYT were calculated by using the formula proposed by Willey (1979). LER was calculated in accordance with (Willey and Osiru, 1972), relative crowding coefficient = RCC (Willey and Rao, 1980), competitive ratio = CR is calculated by the formula Willey *et al.,* (1980) and aggressivity index = AI) is a ameasurement form of the competition relation between two plants in the mixed planting (polyculture) (Wiley, 1979)

## Results

### *Effect of Cropping System on Dry Matter Yield and Crude Protein Content*

The summary of statistical analysis of data for dry matter yield, crude protein content is shown in Table 1. Cropping system caused significant response ($P<0.05$) on dry matter yieldand crude protein content (Table 1). Dry matter yield of sole sorghum was significantly hihger ($P<0.05$) than the sorghum-centro intercropping andsole centro. Crude protein contentof sole centro was significantly hihger ($P<0.05$) than the sorghum-centro intercropping and sole sorghum.

**Table 1:** Effects of cropping systems ondry matter yield and crude proteincontent.

| Parameters | Cropping system | Fertilizer | | Average | Probability | SEM |
|---|---|---|---|---|---|---|
| | | P0 | P1 | | | |
| Yield (g/pot) | Sole crop of Sorghum | 17.36 | 24.77 | 21.07$^{a}$ | 0.000 | 1.099 |
| | Sole crop of Centro | 6.66 | 13.33 | 10.00$^{c}$ | 0.000 | 1.099 |
| | Sorghum–centro (2:2) | 12.82 | 18.80 | 15.81$^{b}$ | 0.000 | 0.457 |
| Crude protein (%) | Sole crop of Sorghum | 6.11 | 7.75 | 7.26$^{c}$ | 0.000 | 0.484 |
| | Sole crop of Centro | 11.77 | 12.70 | 11.79$^{a}$ | 0.000 | 0.000 |
| | Sorghum–centro (2:2) | 6.86 | 7.84 | 8.69$^{b}$ | 0.000 | 0.457 |

$^{abc}$: the different superscripts within the column indicate differences ($p<0.05$).

### *Effect of Bio-Slurry Fertilizer on Dry Matter Yield and Crude Protein Content*

The effect of bio-slurry fertilizer on the dry matter yield crude protein content of sorghum-centro intercropping system is presented in Table 2. Application of bio-slurry fertilizer increased ($P<0.05$) dry matter yield and crude protein content of sorghum sole and centro sole as well as sorghum-centro intercropping, compared without fertilizer (control). The increasd dry matter and crude protein content as a result of bio-slurry fertilizer were 54% and 14%, respectively.

**Table 2:** Effects of bio-slurry Fertilizer on the production of dry matters and crude protein Content.

| Parameters | Fertilizer | SS | CS | S:C (2:2) | Avrg | Prob. | SEM |
|---|---|---|---|---|---|---|---|
| Yield (g/pot) | P0 | 17.36 | 6.66 | 12.82 | 12.28$^{b}$ | 0.000 | 0.969 |
| | P1 | 24.77 | 13.33 | 18.80 | 18.97$^{a}$ | 0.000 | 0.859 |
| Crude protein (%) | P0 | 6.11 | 11.77 | 6.86 | 8.25$^{b}$ | 0.048 | 0.403 |
| | P1 | 7.75 | 12.70 | 7.84 | 9.43$^{a}$ | 0.048 | 0.357 |

SS = Sole crop of Sorgum, CS = Sole crop of Centro, S:C = sorghum–centro intercropping (2:2), SEM = Standard Error of Mean.

### *Competitiveness*

*Relative Yield ( RY) and Relative Yield Total (RYT)*

Relative yields (RY) and (relative yield total (RYT) of centro and sorghum in intercropping systems are presented in Table 3. In Table 3, it appears that RY sorghum (RYS) and RY centro (RYC) at P0 and P1 value are less than one (<1). The RYT valuewas observed were 0.99 (P0) and 0.89 (P1) in treatments (2:2).

**Tabel 3:**Pengaruhpemberianpupukbio-slurry terhadaphasilrelatifsorgum (RYS), hasilrelatifcentro (RYC) andhasilrelatiftotal (RYT).

| Fertilizer | YSS | YSI | YCS | YCI | RYS | RYC | RYT |
|---|---|---|---|---|---|---|---|
| P0 | 17.36 | 11.36 | 6.66 | 2.29 | 0.65 | 0.34 | 0.99 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| P1 | 24.77 | 17.49 | 13.33 | 2.48 | 0.71 | 0.19 | 0.89 |

YSS = yield sorghum as sole crops, YSI = yield sorghum as intercrop, YCS = yield Centro as sole crops, YCI = yield Centro as sole intercrops.

*Land Equivalent Ratio (LER)*

The effects of bio-slurry Fertilizer on the value of land equivalent ratio (LER) in intercropping system of sorghum-centro (2: 2) are presented in Table 4.The value of land equivalent ratio (LER) is smaller than one (<1).

**Tabel 4:**Pengaruhpemberianpupuk bio-slurry terhadap Land equivalent ratio (LER), Relative Crowding Coefficient (RCC), Competitive ratio (CR) danIndeksAgresivitas (AI).

| **Fertilizers** | **LER** | | **LER TOTAL** | **RCC** | | **CR** | | **AI** | |
|---|---|---|---|---|---|---|---|---|---|
| | S | C | | S | C | S | C | S | C |
| P0 | 0.65 | 0.34 | 0.99 | 4.61 | 0.64 | 1.91 | 0.52 | 0.15 | -0.15 |
| P1 | 0.71 | 0.19 | 0.90 | 4.24 | 0.69 | 3.74 | 0.27 | 0.27 | -0.27 |

S = *Sorghum*, C = *Centro.*

*Relative Crowding Coefficient (RCC)*

The impact on competition and the advantages of intercropping are determined by calculating the coefficient of relative crowding. The values of relative crowding coefficient (RCC) of sorghum and centroplanted with intercropping system are presented in Table 4. The RCC value of sorghum is higher than that of centroof both treatments i .e without Fertilizer (P0) and with Fertilizer (P1).

*Competitive Ratio (CR)*

The effects of bio-slurry fertilizer on the competitive ratio between sorghum and centro are presented in Table 4. The competitive value in the fertilizer application of 3.74 (P1) indicates that this competitive ratio of sorghum-centro intercropping is the highest and the value of 1.91 indicates the lowest competitive ratio in the treatment without fertilizers (P0).

*AggressivityIndex (AI)*

The experiment showed that aggressivity index at intercropping sorghum-centro (2:2) showed that the two species have the same numerical value, but different signs. Sorghum aggressiveness index (+0.15) and centro (-0.15) in the treatment without fertilizer (control). Application of bio-slurry fertilizer increased indices aggressiveness of sorghum (+0.27) and centro of (-0.27).

## Discussion

Differences in forage yield between of sorghum and centro may be attributed by different in species. Sorghum growing faster and capable of producing a higher dry matter rather than centro. The overall results indicated that dry matter yield of sorghum grown in association with centro was lower than the sole crop of sorghum which was probably the result of plant competition for the nutrients. According to Buxton and Fales (1993) that the interplant competition usually includes competition for soil water, available nutrients, and solar radiation. Siddig *et al.* (2013) reported that dry matter weight of sorghum was influenced due to sorghum-ground nut intercropping. In contrast, other researchers have reported that dry matter yield of sorghum greater when grown with groundnuts (Krishna *et al.,* 1998 and Ayisi *et al.,* 2001). Application of bio-slurry increased response ($P<0.05$) on dry matter yield of sorghum sole, centro sole and sorghum-centro intercropping. The responses are due to the addition of soil nutrients derived from bio-manure slurry. According Mburu (2012) that the urine (slurry) is a source of macro nutrients such as NPK and other elements needed by plants. Increasing the level of slurry nitrogen presumably increased the availability of soil nitrogen, and that of other macro- and micronutrients, which might have enhanced meristematic growth and resulted in higher fodder yield (Islam *et al.,* 2010). Effect of bio-slurry on the growth and production of crops has been reported by several investigators. The utilization of cow-bio-urine promotes plant growth and yield in crops of eggplant (Cardoso *et al.,* 2009), corn (Devakumar *et al.,* 2014), carrots and okra (Muhmood *et al.,* 2015) and the elephant grass and Setaria (Nuriyasa *et al.,* 2012).

Application of bio-slurry increased response ($P<0.05$) on dry matter yield of sorghum sole, centro sole and sorghum-centro intercropping. The responses are due to the addition of soil nutrients derived from bio-manure slurry. Urine (slurry) is a source of macro nutrients such as NPK. Increasing the level of slurry nitrogen presumably increased the availability of soil nitrogen, which might have enhanced meristematic growth and resulted in higher fodder yield (Islam *et al.,* 2010 and Mburu, 2012 ). Bio-slurry can play an important role as a source of nutrients for crop production. Compared to manure, nutrients in bio-slurry (especially nitrogen) are more readily available, which means that bio-slurry can have a larger fertilization effect in short term (Bonten *et al.,* 2014). Effect of bio-slurry on the growth and production of crops has been reported by several investigators.

The utilization of cow-bio-urine promotes plant growth and yield in crops of napier grass and Setaria (Nuriyasa *et al.,* 2012), eggplant (Cardoso *et al.,* 2009), corn (Devakumar *et al.,* 2014), carrots and okra (Muhmood *et al.,* 2015),legume crop puero (Mudhita *et al.,* 2016). Application of bio-slurry increased response ($P<0.05$) on dry crude protein content of sorghum sole, centro sole and sorghum-centro intercropping. The applications of dry bioslurry o increase crude protein content in maize (Rahman *et al.,* 2008) and grass (Mikled *et al.,* 2002). Sorghum-centro intercropping improves the overall quality of forage quality, because legumes play an important role in the supply of nitrogen. Legumes have the ability to fix N2 from the air so that they have a higher protein content. As with other legums, centro can improve soil fertility through nitrogen fixation, and nitrogen fixation by legumes begins with the formation of nodules. The results of this study indicate that the centro is able to form nodules. It is able to fixate the equivalence of 67 kg N/ha and can transfer N at 5 kg/ha on the mixed crops of guinea-centro (Reynolds, 1982). Planting grass along with legumes is helpful in producing grass since Fertilizer is not necessary (Castillo *et al.,* 2003). Crude protein content of the non-legume crops can be increased if planted with plants from the legume family (Eskandari *et al.,* 2009).

According to De Wit (1960), that if the values of RY (species A) and RY (species B) are both less than one (<1), it is evident that there is a mutual antagonism between the competitors. If one species is reduced, then there are many resources available for other species. This shows that there is a mutual antagonism between the centro and sorghum in intercropping. According to Williams and McCarty, 2001) if one species is reduced by 30% in the mixed crops, then the RY value is 0.7; however, If the species has experienced a 30% increase in the mixed crops, then the RY value is 1.3. Relative yield total = RYT (Table 3) showed that the values of RYT on the treatments without fertilizer (P0) and with fertilizer (P1) were less than one (<1).

According to Silvertown and Lovett Doust (1993), when the RYT value is 1.0, then there is a competition between species to get the same resources; however, if RYT value is greater than one (>1), then there are plant species that avoid competition to occur; and if the RYT value is less than one (<1), there is a mutual antagonism between plant species. This shows that sorghum and centro planted together in polybag have decreased their dry matter production. The decline is due to competition for limited resources that exist in the growing media.

The land equivalent ratios (LERs) were assessed in terms of dry matter production of two treatments used. Results showed that the LER values of dry matter production for both sorghum-centro mixtures substantially less that of their corresponding monoculture. Since the idea of land equivalent ratio in most cases, is the most important comparison between yield of the main crop in mixture and its yield in pure stand, it is rather expected that the combination of component species in mixture will be more productive than the species grown as a sole crops. The result obtained were not in accordance with the definition of land equivalent ratio in that the combination of component species in the mixture were more productive than the same species when grown as sole crops. The LERs ratio, in P0 (0.99) and P1 (0.90) treatments, were less than 1, the sole which interpreted as disadvantage of mixture over sole crop. Because it is less than one (<1), it will give a negative effect on growth and yield (Ofori and Stern 1987). This condition indicates that the cropping patterns of sole centro or sole sorghum will provide greater results than those by the intercropping of sorghum-centro. According to Mead and Willey (1980), LER shows the efficiency of intercropping in using resources from the environment is greater compared that of sole planting. Ghosh (2004) reported that the Veth-barley mixture and mix Veth-triticale showed losses compared with pure stands.

The aggressiveness of one species towards another demonstrates bythe value of relative crowding coefficient (RCC). Plant components that have a higher relative crowding coefficient (RCC) value is more dominant. To determine if there are any profits from the yields of cropping systems, the coefficient values of both plant components must be obtained. If the value of relative crowding coefficient (RCC) of the two species is of the same value, then it means that the planting system does not have any advantages. Intreatments (P0) and (P1), sorghum appeared to be highly dominant as it had higher value of RCC than the intercrops in different intercropping sorghum system (Table 4).

If the value of the RCC is less than one, then the planting system has some weaknesses/shortcomings; however, and if the value of RCC is more than one (> 1), then the planting system has advantages or benefits. In this study, the biggest advantage recorded is from sorghum which was treated both by fertilizers (P1) and without Fertilizer (P0) their RCC values were 4.24 and 4.61 respectively. It can be inferred that the intercropped sorghum utilized the resources more competitively andcentroappeared to bedominated.

The effects of bio-slurry fertilizer on the competitive ratio between sorghum and centro are presented in Table 4. The competitive value in the fertilizer application of 3.74 (P1) indicates that this competitive ratio of sorghum-centro intercropping is the highest and the value of 1.91 indicates the lowest competitive ratio in the treatment without fertilizers (P0). This indicates that the bio-slurry fertilizer in intercropping sorghum-centro (2:2) promotes the growth of sorghum and suppress the growth of centro. In all mixtures, a positive sign of sorghum showed that sorghum was dominant species in the mixture (Table 4). Intercropping sorghum-centro has CR 1.91 for sorghum and 0.52 for the centro. Application of bio-manure slurry increases to CR sorghum 3.74 and decreased to CR centro 0.27. High competitive value ratio (CR) indicates high level of competition between plants intercropped. Ariel *et al.,* (2013) state that the more dense the composition of plants in the intercropping, the higher the competition

Aggressivity index is used to determine the magnitude of the competition relationship in mixed cropping systems (Willey, 1979). The aggressivity index (AI) of sorghum-centro intercropping fertilized by bio-slurry fertilizer (P1) and without fertilizer (P0) showed that sorghum has a positive sign (+) while centro has a negative sign (-) (Table 4). The positive sign on sorghum showed that it was dominant while the negative sign (-) on centro indicated that centro was being dominated (weak). Dhima *et al.,* (2007) state that the zero value of aggressivity index indicated that the plant components were equally competitive. If a plant has the same numerical value, the positive sign (+) indicates the dominant species (strong), while the negative sign (-) showed that a species is being dominated (weak). This shows that sorghum is more dominant than centro planted in polybags.

## Conclusion

Fertilizer using bio-slurry increases the production of dry matter and crude protein content of sorghum and centro planted with a monoculture system and sorghum-centro planted with a polyculture system. Sorghum treated by bio-slurry fertilizer is more dominant as shown by its high values of the relative crowding coefficient, competitive rates and positive sign of agressivity. Sorghum has grown more aggressively than centro in utilizing resources.

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